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EXTERNAL REFERENCE

IT Technical Specifications

Plant system I&C Integration plan

This document describes the testing approach and methods and the organizational schemefor planning and performing the FAT and SAT for any ITER I&C system.

Approval Process			
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Plant system I&C Integration plan (3VVU9W_v4_4)	v4.4	Signed	15 Apr 2013	Introduction of the plant system I&C - central I&C interface tests in IO CSD lab
Plant system I&C Integration plan (3VVU9W_v4_3)	v4.3	Approved	17 Jan 2013	Version reviewed for quality. Technical content is not changed with respect to 4.2 Version issued in scope of PCDH v7

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				}

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Plant system I&C Integration plan (3VVU9W_v3_0)	v3.0	Signed	12 Oct 2012	A number of improvement in wording, simplification. section 2.5 added, campaign for SDD merged to SW campaign. Scenario reduced by pushing most of the requirement check at design and manufacture phase
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Plant system I&C Integration plan (3VVU9W_v2_4)	v2.4	Signed	18 Apr 2012	Minor changes
Plant system I&C Integration plan (3VVU9W_v2_3)	v2.3	Signed	17 Apr 2012	Version issued after Anders and Izuru review
Plant system I&C Integration plan (3VVU9W_v2_2)	v2.2	Signed	04 Apr 2012	Version completed by JY and requiring now the veview/completion of stakeholders mentionned in the text.
Plant system I&C Integration plan (3VVU9W_v2_1)	v2.1	Signed	14 Sep 2011	Intermediate version used in scope of CWS I&C meeting on 14th of September
Plant system I&C Integration plan (3VVU9W_v2_0)	v2.0	In Work	08 Jul 2011	Still in work, changes for simplification plus alignment with PCDH v6.1, still interlock and safety areas to complete and review.
Plant system I&C Integration plan (3VVU9W_v1_5)	v1.5	Approved	09 Feb 2011	Version issued after PCDH v6 external review
Plant system I&C Integration plan (3VVU9W_v1_4)	v1.4	Signed	09 Feb 2011	Updated following JYJ comments stored in IDM with version 1.3
Plant system I&C	v1.3	Signed	09 Feb	Version after PCDH v6 external review

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Plant system I&C Integration plan (3VVU9W_v1_1)	v1.1	Signed	06 Jan 2011	THIS VERSION IS UPLOADED FOR PCDH v6 DOCUMENTATION PACKAGE REVIEW ONLY!
Plant system I&C Integration plan (3VVU9W_v1_0)	v1.0	Signed	29 Nov 2010	

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Document Revision History

Version	Status	Date	Changes
1.0	Draft	19/08/2010	Initial version issued in scope an engineering support contract
1.1	Draft	30/08/2010	Enhancements, including outcomes of 23rd of August review with JY Journeaux in Cadarache
1.2	Draft	17/09/2010	Draft issued for 2nd review by CSD team
1.3	1st official Version	08/10/2010	Updates as per: Antonio Fernandez and Izuru Yonekawa review forms Outcomes of 24th of Sept review meeting in Cadarache
1.4	Updated	16/11/2010	Updated following JYJ comments stored in IDM with version 1.3
1.5	Updated	15/12/2010	Removed Pulse scheduling interface
2.0	Updated	15/04/2011	After this date the versions have been issued directly by IO. JYJ changes for simplification plus alignment with PCDH v6.1, still interlock and safety areas to complete and review.
2.1	In work	15/10/2011	Completion of chapter 4, still the inputs from Denis, Bruno, Nadine, Petri, Hitesh, Antonio, Jean-Marc to incorporate.
2.2	In work	04/04/2012	Scope enlarged to PS I&C integration, alignment with CODAC DDD for the integration scheme.
3.0	In work	27/09/2012	A number of improvements in wording plus section 2.5 added, C2 merged with C4. Campaign scenarios simplified.
4.0	In work	12/12/2012	Version submitted to J Poole review
4.3	Final	17/01/2012	Version issued in scope of PCDH v7
4.4	Final	23/01/2013	Introduction of SDD tests in chapter 3
4.5	Final	12/03/2013	Introduction of interface tests in chapter 3

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1 Introduction

1.1 Document purpose

This document, part of the Plant Control Design Handbook (PCDH) satellite documents package, is a handbook for specifying the procedures for the Factory Acceptance Tests (FAT) and Site Acceptance Tests (SAT) for plant I&C systems.

Chapter 2 describes the integration model for I&C systems, chapter 3 provides details for the FAT, chapter 4 is dedicated to I&C assembly, chapter 5 provides details for the SAT, chapter 6 proposes acceptance criteria but these must be aligned with the IO criteria when they are available, chapter 7 provides technical details for the test procedures, chapter 8 list the requirements to be checked at design and manufacture phase and chapter 9 provide the complete PCDH requirement mapping matrix for FAT and SAT.

PCDH comprises a core document which presents the plant system I&C life cycle and recaps the main rules to be applied to the plant system I&Cs for **conventional controls, interlocks and safety controls.** Some I&C topics are explained in greater detail in dedicated documents associated with PCDH. These are presented in Figure 1-1 and this document is one of them.

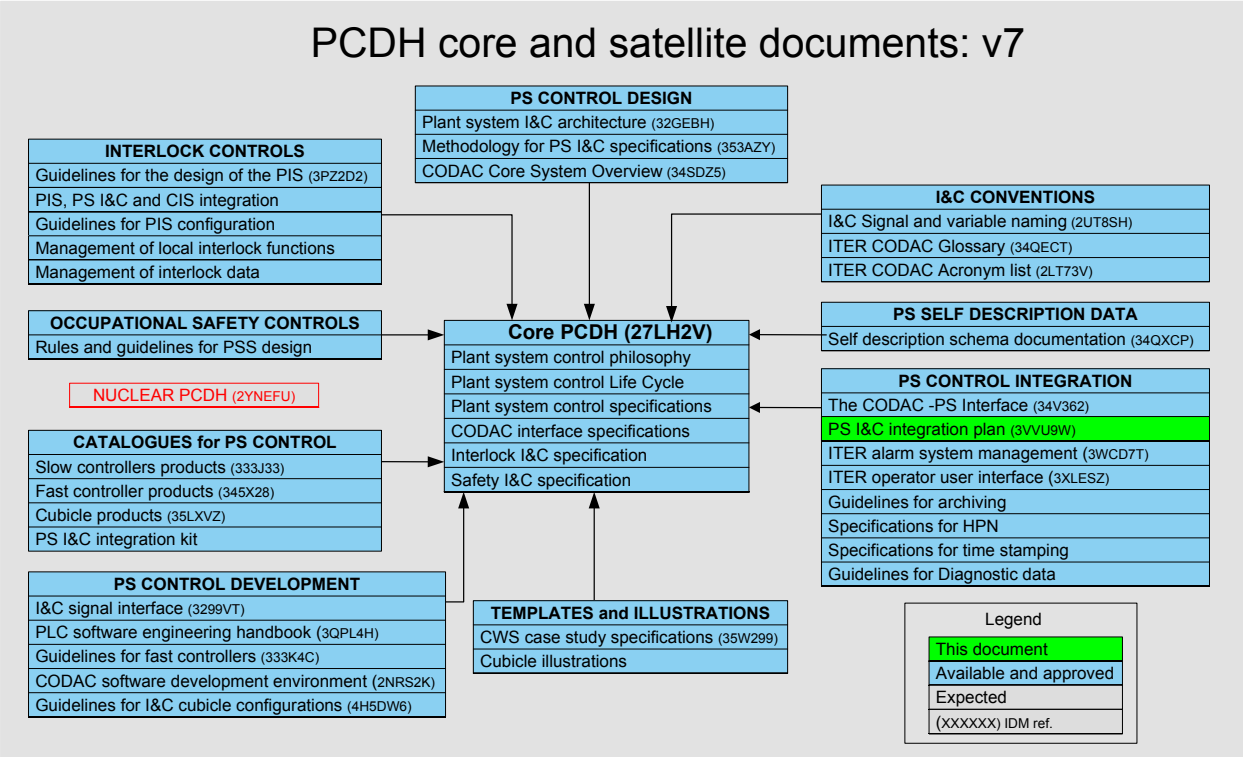
PCDH core and satellite documents: v7
PS CONTROL DESIGN
Plant system I&C architecture (32GEBH)
Methodology for PS I&C specifications (353AZY)
CODAC Core System Overview (34SDZ5)
INTERLOCK CONTROLS
Guidelines for the design of the PIS (3PZ2D2)
PIS, PS I&C and CIS integration
Guidelines for PIS configuration
Management of local interlock functions
Management of interlock data
I&C CONVENTIONS
I&C Signal and variable naming (2UT8SH)
ITER CODAC Glossary (34QECT)
ITER CODAC Acronym list (2LT73V)
OCCUPATIONAL SAFETY CONTROLS
Rules and guidelines for PSS design
Core PCDH (27LH2V)
Plant system control philosophy
Plant system control Life Cycle
Plant system control specifications
CODAC interface specifications
Interlock I&C specification
Safety I&C specification
PS SELF DESCRIPTION DATA
Self description schema documentation (34QXCP)
NUCLEAR PCDH (2YNEFU)
PS CONTROL INTEGRATION
The CODAC -PS Interface (34V362)
PS I&C integration plan (3VVU9W)
ITER alarm system management (3WCD7T)
ITER operator user interface (3XLESZ)
Guidelines for archiving
Specifications for HPN
Specifications for time stamping
Guidelines for Diagnostic data
CATALOGUES for PS CONTROL
Slow controllers products (333J33)
Fast controller products (345X28)
Cubicle products (35LXVZ)
PS I&C integration kit
PS CONTROL DEVELOPMENT
I&C signal interface (3299VT)
PLC software engineering handbook (3QPL4H)
Guidelines for fast controllers (333K4C)
CODAC software development environment (2NRS2K)
Guidelines for I&C cubicle configurations (4H5DW6)
TEMPLATES and ILLUSTRATIONS
CWS case study specifications (35W299)
Cubicle illustrations
Legend
This document
Available and approved
Expected
(XXXXXX) IDM ref.

Figure 1-1: PCDH document package

1.2 Acronyms

AI	Analogue Input
AO	Analogue Output
CENTRAL I&C	Addition of PBS45, 46 and 48
CIN	Central Interlock Network
CIS	Central Interlock System
CODAC	COntrol Data Access and Communications
COS	Common Operating State
COTS	Commercial Off The Shelf
CPU	Central Processing Unit
CSN	Central Safety Networks
CSD	Control System Division of IO
DA	Domestic Agency
DI	Digital Input
DO	Digital Output
EMC	Electro-Magnetic Compatibility
EPICS	Experimental Physics and Industrial Control System
FAT	Factory Acceptance Test
HPN	High Performance Networks
HW	Hardware equipment or part
I&C	Instrumentation & Control
I&C SU	I&C Supplier
IEC	International Electro-technical Commission
I/O	Input / Output
IO	ITER Organization
NTP	Network Time Protocol
PA	Procurement Arrangement
PCIe	Peripheral Component Interconnect express
PIS	Plant Interlock System
PCDH	Plant Control Design Handbook
PLC	Programmable Logic Controller
PON	Plant Operation Network
PS	Plant System
PSOS	Plant System Operating State

PSH	Plant System Host
PSS	Plant Safety System
PSE	Plant System Equipment
PS I&C RO	Plant System I&C Responsible Officer
PV	Process Variable
RIO	Remote IO chassis
RO	Responsible Officer
SDN	Synchronous Data-bus Network
SDD	Self-Description Data
SIL	Safety Integrity Level
SSEN	Steady State Electrical Network
SW	Software package
TBC	To Be Confirmed
TBD	To Be Defined
TCN	Time Communication Network

1.3 Conventions

Throughout this document mandatory rules (or requirements) are enumerated and prefixed with R. Non mandatory guidelines (or recommendations) are enumerated and prefixed with G. The table below provides a list of paragraph identifiers used in this document.

AD	Applicable Document
D	Deliverable for a lifecycle phase
G	Guideline / Recommendation
R	Rule / Requirement
RD	Reference Document
SD	Satellite Document

Paragraphs marked with TBD or TBC represent work in progress which will be confirmed and expanded further in subsequent releases of this document.

1.4 Reference documents

The following documents are cited in this document:

[RD1] Plant Control Design Handbook (27LH2V)
[RD2] IO cabling rules, (335VF9)
[RD3] ITER On-Site Testing Strategy (44U2Y4)
[RD4] ITER Policy on EEE in Tokamak Complex (6ZX6S3)
[SD1] Plant System I&C Architecture (32GEBH)
[SD2] Methodology for PS I&C specifications (353AZY)
[SD3] I&C signal and variable naming convention (2UT8SH)
[SD4] Self description schema documentation (34QXCP)
[SD5] The CODAC - Plant System Interface (34V362)

[SD6] PS I&C integration plan (this document) (3VVU9W)
[SD7] ITER operator user interface (3XLESZ)
[SD8] ITER alarm system management (3WCD7T)
[SD9] I&C signal interface (3299VT),
[SD10] PLC software engineering handbook (3QPL4H)
[SD11] Software engineering and QA (2NRS2K)
[SD12] Slow Controller catalogue (333J63)
[SD13] Guidelines for fast controllers (333K4C)
[SD14] Fast Controller products catalogue (345X28)
[SD15] Cubicle products catalogue (35LXVZ)
[SD16] Guidelines for the design of the PIS (3PZ2D2)
[SD17] CWS case study specifications (35W299)
[SD18] ITER CODAC glossary (34QECT)
[SD19] ITER CODAC Acronym list (2LT73V)
[SD20] CODAC Core System Overview (34SDZ5)
[SD21] Plant Control Design Handbook for Nuclear control systems (2YNEFU)
[SD22] Management of local interlock functions (TBD)
[SD23] Guidelines for diagnostic data structure and plant system status information (TBD)
[SD24] Guidelines for I&C Cubicle Configurations (476HUG)

2 The model of integration of I&C systems

2.1 The Plant System I&C life-cycle

The plant system I&C life-cycle is detailed in PCDH [RD1], Section 3. This life-cycle includes the following phases for any procurement package:

1. A design phase for definition of the technical requirements.
2. A manufacturing phase which includes Factory Acceptance Tests (FAT) at supplier premises.
3. An integration phase which comprises the following sub-phases:
   a. Installation on ITER site.
   b. Site Acceptance Tests (SAT) testing all procured plant systems connected together.
   c. Integrated commissioning to test of the complete plant system once it is functionally and physically integrated with the CENTRAL I&C infrastructure and other plant systems.
4. Plant system operation.

In the ITER procurement model, a plant system is split into one or several procurement packages delivered as contributions in kind by DAs or purchased from IO suppliers. Following the plant system design phase, an approved design is agreed by DA and IO (in kind procurement only) and each procurement package follows its own life-cycle for phases 2 and 3a. Then the procurement package is tested as an integrated system at the time of the SAT.

As a general rule, I&C equipment (HW + SW) required to control the procurement package is included in a part of the procurement deliverables. Therefore PCDH requirements apply on this I&C equipment and shall be considered at FAT and SAT as a part of the approved design requirements. Therefore only PCDH requirements are considered in that document.

2.2 Plant system I&C integration model

The unit of integration into CODAC systems is the plant system I&C.

Several plant system I&Cs may be required to control a plant system and then several integration processes might be required to integrate a plant system in CODAC systems. See [SD1] for definition of the plant system I&C.

As a consequence of the ITER procurement model and also from the plant system I&C perspective it is necessary to also consider the unit of procurement (the PA) in the plant system I&C integration model. Therefore, the model of I&C integration starts at PA level and ends up at plant system I&C level.

The starting point of the integration is the completion of the Factory Acceptance Tests (FAT). From that point on, the ITER model for on-site testing applies, see [RD3] for further details. This model introduces the following sequence: site delivery - site reception - assembly - component tests - system tests - system commissioning - ITER integrated commissioning.

The Site Acceptance Test (SAT) is when IO decides whether to accept or reject the component on the basis of the test results. The SAT will be initiated at site reception and will terminate at system commissioning.

Note: the final acceptance by IO of the procurement package may require additional tests to be executed during ITER integrated commissioning (typically the case for performance tests and compliance with environmental conditions).

This document will focus on the procedures to be executed on the procurement package during the FAT and on plant system I&C during the SAT in order to integrate the plant system I&C with CODAC systems.

2.3 I&C system configuration types for the procurements

See [SD1] for definition and configuration of the plant system I&C.

There are three I&C configurations of procured equipment as a consequence of the procurement model and plant system sharing:

- Configuration#1: The interface for I&C is the CODAC infrastructure as defined in PCDH. This configuration is the IO standard model: the equipment is delivered as standalone plant system I&C which is ready to be integrated. Typical examples are the buildings, the liquid nitrogen cryoplant, the heating and diagnostic neutral beam facilities and some diagnostic systems. See Figure 2-1, PA1.
- Configuration #2: The interface for I&C is still the CODAC infrastructure as defined in PCDH, but the procurement is a part a more extended plant system I&C. The I&C procurement is still delivered as a PCDH compliant system, including a PSH and a mini CODAC like configuration#1 but this configuration assumes some integration work will be performed by IO to complete the integration of the PS I&C (e.g. merging of mini CODAC and PSH configurations). Typical examples may be found in the cryogenics and the water cooling plant systems. See Figure 2-1, PA2.
- Configuration #3: The interface for I&C is reduced to the signals provided by the sensors/actuators or any controller embedded in the equipment . This configuration is typically used when the plant I&C system is purchased by IO. A typical example is the Magnet system. See Figure 2-1, PA3.

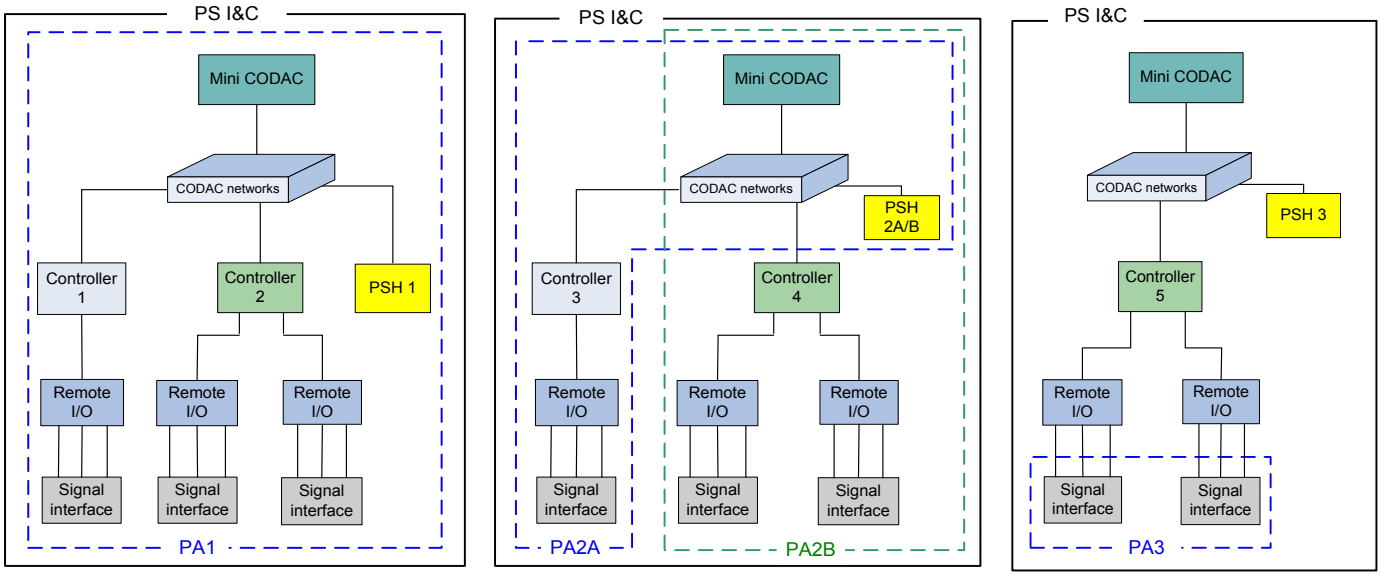

Figure 2-1: I&C configuration types

2.4 I&C actors for FAT and SAT

Several actors are involved in FAT and SAT for I&C. Those introduced in this document are:

- **Plant System I&C Responsible Officer** (PS I&C RO) – IO client of the I&C system. He/she provides the plant system inputs throughout the design process. He/she reviews the plant system I&C design, provides the PS I&C FAT and SAT plans, reviews and approves the results of the PS I&C FAT and SAT. He/she is supported by the ITER Control System Division (CSD) for checking compliance with PCDH requirements and implementation of CODAC solutions.
- **Procurement I&C Supplier** (I&C SU) – supplies any I&C equipment or software including spare units and documentation for the plant system in question. The scope of the supply is defined in Annex B of the PA (in-kind procurement) or the technical specifications (when purchasing). The configuration of the PSH and Mini-CODAC is a task of the procurement I&C SU, therefore the procurement I&C SU is assumed to be skilled in using CODAC tools. The procurement I&C SU executes the PS I&C FAT and SAT plans.

2.5 I&C deliverables and rules to be considered throughout the plant system I&C life-cycle

Phase Topic	Design	Manufacture and FAT	Install.	SAT	Integrated commissioning & operation
PCDH deliverables for I&C	• **D1** Plant system I&C architecture. • **D5** Plant system controller(s) performance and configuration requirements. • **D6** List of inputs and outputs (I/O) of the I&C controllers. • **D7** List of the Process Variables handled by the plant system I&C controllers. • **D8** Configuration of I&C cubicles. • **D9** Specifications of plant system operating state machines.	• **D31:** Functional specifications of the I&C system developed within the scope of the procurement. • **D32:** SW documents and files specified in the section 4.4 of PCDH. • **D34:** Technical documents for specifying the internal configuration and cabling of the I&C cubicle. • **D39:** Procedure for installation of all hardware and software packages. • **D40:** All original documents for mounting, cabling, configuring, operating and maintaining any I&C equipment. • **D41:** Drawings showing the complete path of I&C signals from the sensors/actuators up to the signal interfaces of the I&C controllers. • **D42:** Calibration factors for the sensors and the actuators. • **D43:** Extension of D40 for specifying the installation, operation and maintenance. • **D44 and D71:** Short term (D44) and long term maintenance and obsolescence management (D71) • **D48:** Certificates of conformity of the I&C equipment. • **D20:** Self-Description Data as described in and [SD4] • **D26:** mini CODAC configuration as required for the operation of the system using CODAC systems and infrastructure. • **D18**: I&C cubicles procured within the scope of the PA. • **D19:** I&C spare parts for maintenance. • **D74:** is gathering all hardware and software tools required to maintain non-standard I&C equipment. • **D72:** user software developed in the scope of the I&C for active control, monitoring, simulation and testing purposes. • **D50:** FAT report	None	• **Update of all deliverables** • **D65:** SAT report	None
PCDH rules for I&C	Related rules are mentioned in sect. 8	Related rules mentioned in sect. 7	None	Related rules are mentioned in sect. 7	None

3 Details of the FAT for I&C systems

3.1 FAT objectives for I&C and entering FAT

The objective of the plant system I&C FAT from the CENTRAl I&C perspective, is to check the readiness of the PA for integration with the CENTRAL I&C.

Procured PA is considered as ready for the FAT if the following criteria are met:

- ✓ The CENTRAL I&C interface data has been made available and updated in the IO Self Description Data (SDD) repository.
- ✓ The PCDH requirements specified for checking during design and manufacture phases are met.
- ✓ The FAT plan is defined and agreed by all parties. The FAT plan must cover all I&C systems interfaced to CENTRAL I&C for conventional, interlock and safety controls.
- ✓ The software deliverables are stored in the correct IO repository.
- ✓ The component list (bill of materials) is issued and it identifies all I&C deliverables as specified in PCDH.
- ✓ All of the certificates required are available.
- ✓ The mini CODAC system is configured and ready to proceed to the FAT.
- ✓ The supplier is ready to proceed.

FAT for I&C will target the remaining PCDH requirements to be checked on the relevant deliverables.

3.2 Scope of FAT for I&C systems

It is proposed to split the FAT for I&C into four campaigns as listed below:

C1. I&C documentation.

C2. I&C hardware.

C3. I&C configuration data and software.

C4. I&C functional requirements.

Each campaign is determined by the PCDH requirements and the I&C deliverables which have to be checked.

A non-compliance severity level has been assigned to each PCDH requirement to be verified during the FAT and SAT: see Section 6.1 for further details.

The details of the campaigns are given in the Chapter 7 of this document.

A mapping between the PCDH requirements and the campaigns is proposed in the Excel file incorporated in Chapter 9.

3.3 Performing FAT for I&C systems

Preparing FAT in IO:

For each PA the following tasks will be performed by IO for testing the PA interfaces with the central I&C systems:

- ✓ Set up the suitable plant system I&C HW architecture matching the PA configuration with all controller CPU chassis connected physically to the central I&C networks in IO lab (no remote IO chassis is required provided there is no central I&C interface expected in the remote IO chassis). The mini-CODAC and the PSH are parts of the architecture.
- ✓ Check the configuration data and procedure of installation (PCDH deliverables are identified for each). The versions of software and SDD deliverables stored in IO repository are used.
- ✓ Test the PA-central I&C interface: The test procedure to apply is still TBD.

For the complete plant system I&C:

- ✓ Set up the complete plant system control system HW architecture as for PA testing.
- ✓ Test the functional links in between PAs involved in the plant system I&C.

Performing FAT at supplier premises:
For efficiency, it is recommended that the campaigns are performed in the order as described in this document.

The campaign C1 does not require any attendance of the PS I&C RO at the FAT site since it may be performed remotely by IO using the deliverable documents. C1 is performed by the PS I&C RO with the support of CSD.

The campaigns C2, C3 and C4 require the attendance of the PS I&C RO at the FAT site and the support of CSD, but will be prepared at IO premises using the PCDH deliverable documents and the bill of materials. C2 to C4 are performed by the I&C SU. See details in Sections 7.4, 7.5 and 7.6.

How to perform the campaigns in the scope of a FAT:

C1. Upload the deliverable documents in IDM/EDB (details are still TBD) and proceed to the review them as specified in Section 7.3 for all items checked in the FAT column of the I&C matrix[1].

C2. Check the deliverables D18 (I&C cubicles), D19 (spare parts for I&C) and D79 (any specific maintenance tools required) as specified in Section 7.4, for all items checked in the FAT column of the I&C matrix[2].

C3. Check the deliverables D20, D26 (SDD configuration data) and D72 (all I&C user software), D74 (the SW tools required for the PS maintenance) as specified in Section 7.5, for all items checked in the FAT column of the I&C matrix[3].

C4. Check the deliverable D39 (HW and SW installation procedure) by executing D39 for complete HW and SW installation as specified in Section 7.6. Check the Central I&C interfaces and all functional requirements as specified in Section 7.6.

On completion of FAT, the FAT report (PCDH deliverable D50) is issued by the I&C SU and the test plan is also updated if required.

4 Details of the assembly of procured equipment for I&C systems

The unit of assembly for any I&C procurement is the I&C cubicle: the I&C is considered as assembled when all I&C cubicles are mounted and physically interfaced, at their final location. The goal of plant system I&C assembly is then to connect and set up the I&C cubicles with the CENTRAL I&C infrastructure, buildings, power supplies and other services in order to get the plant system I&C ready for the functional tests expected in SAT; the procurement assembly phase is performed under the responsibility of the procurement supplier. The following tasks will be completed on each plant system I&C cubicle:

- ✓ Configure the I&C cubicle for mounting and cabling: to prevent damage, the fragile internal components are first removed, see [SD24] for details.
- ✓ Install the I&C cubicle at its final location in the ITER building.
- ✓ Cable the cubicle to the plant system equipment, to the CENTRAL I&C infrastructure (networks), to the main power supply and to any other system required.
- ✓ Complete the configuration of the HW internal and enclosure if some equipment had been removed before mounting and cabling (fragile component, doors, …)

[1] All document deliverables are expected to be reviewed at FAT.
[2] All HW related rules are expected to be checked at FAT except the rules R59, R312, R313 and R315 which will be checked at SAT.
[3] All SW related rules are expected to be checked at FAT.

5 Details of SAT for I&C systems

5.1 SAT objectives for I&C

From the CENTRAL I&C perspective, FAT target the plant equipment and SAT the plant system I&C. Therefore the SAT objective is to check the readiness of the plant system I&C for integration with CENTRAL I&C systems and infrastructure and to check the readiness of the plant system I&C for integrated commissioning.

5.2 Scope of SAT for plant system I&C

The scope of SAT is identical to that of the FAT but extended to the plant system I&C, in particular where plant system I&C comprises several procurements.

Some things may not be carried out during the FAT and as a consequence shall be transferred to the SAT: The ultimate goal is to have checked all PCDH requirements by the completion of the SAT. By convention, nothing is redone at the SAT when it has already been satisfied during the FAT and there is no I&C configuration change from FAT to SAT.

Therefore the C1 campaign for documentation is not expected to be redone at SAT.

The SAT is organized in three steps: component tests and system tests as specified by [RD3] and a third step for connection to the CENTRAL I&C infrastructure.

5.3 Performing SAT for plant system I&C

To make a complete check of the installation procedure, all of the software and configuration data installed in controllers, mini-CODAC systems and PSH in the scope of the FAT will be deleted. The equipment will be re-installed from scratch using CENTRAL I&C procedures for systems; CENTRAL I&C source repository (SVN) files; configuration data; and the PCDH deliverable D39, for the plant system I&C installation procedure.

Component tests:

The unit for component tests is the I&C cubicle of the plant system I&C. The goal of I&C cubicle tests is to check the physical interfaces with CENTRAL I&C, buildings, power supplies and other services in order to get the plant system I&C ready for the system tests; the component tests are performed by the I&C SU under the responsibility of the PS I&C RO with support from the CSD throughout the following:

- ✓ Carry out the electrical hazard safety inspection to obtain authorization for cubicle powering; proceed to cubicle powering, check the cubicle cooling system. Once this has been done, the I&C cubicle is considered as ready for the next step.
- ✓ When all plant system I&C cubicles are ready, check the network configuration and connectivity of all controllers (PSH included) for PON, TCN, SDN, AVN, DAN, CIN and CSN. Download the SW configurations required for these tests to the I&C controllers. From that point, all active controls are disabled at the controller level to avoid any unexpected automatic action which could potentially disturb the tests or even damage the plant system.
- ✓ It is assumed that the component tests are performed with the mini-CODAC. Then the mini-CODAC configuration will be adjusted to match the component test scenario. Several mini-CODAC systems might be required to execute the system tests, depending on the complexity of the plant system I&C: these should be installed at the appropriate location defined by the PS I&C RO.
- ✓ Check the PSH hardware configuration.
- ✓ Execute the C2 campaign for HW and C3 for SW for all items expected to be checked at SAT and all items not checked at FAT. See details in Sections 7.4 and 7.5.
- ✓ Check the connectivity of the remote IO chassis with the CPU chassis for all controllers of the plant system I&C: this procedure is still TBD.
- ✓ Report the plant system I&C installation issues in the appropriate logging system (details are still TBD), fix the remaining issues. The plant system I&C is then considered ready for the system tests.

System tests:

The unit of system tests for I&C is the plant system I&C. The plant system I&C tests are part of plant system tests; they concern the tests to be performed on plant system I&C to get it ready to complete the system tests. The plant system I&C tests are performed by the I&C SU under the responsibility of the PS I&C RO with support from the CSD throughout the following:

- ✓ If several PSH have been introduced for dealing with a plant system I&C configuration delived in several PAs by different partners, then these PSH shall be merged in only one at that point.
- ✓ Execute the C4 campaign for functional requirements of all items checked in the SAT column in the spread-sheet and all items not checked during the FAT. See details in Section 7.6.
- ✓ Report the plant system I&C test issues in the appropriate logging system (still TBD), fix the remaining issues.
- ✓ Issue the plant system I&C SAT report: PCDH deliverable D65.
- ✓ Enable the active controls in the controllers, the plant system I&C is then considered as ready to complete the system tests under the responsibility of the plant system RO. This point is beyond the scope of this document.

System connection to CENTRAL I&C and preparation for integrated commissioning:

The unit of system connection for I&C is the plant system I&C. After completion of the system tests, the central I&C systems are updated with the plant system I&C data configuration for allowing the plants system I&C to be operated from the Main Control Room (MCR); the plant system I&C mini-CODAC(s) used for plant system I&C SAT are cancelled and removed from the plant system I&C. The PSH HW delivered in scope of the integration kit is removed from the plant system I&C cubicles and is virtualized in CENTRAL I&C systems.

If several plant system I&Cs are involved in the control of the plant system, an additional step targeting the integrated operation of these plant system I&Cs will be performed following the completion of each individual. This integrated operation is performed from the main control room under the responsibility of the PS I&C RO who will specify the scope and the procedure for these tests.

6 I&C Acceptance Principles

6.1 Issue management

During the execution of tests, any deviation from the expected result must be captured in a uniquely identified issue sheet. All the information related to the investigation of the root cause of the issue and all the remedial actions must be recorded in the sheet. The PCDH rules in Section 7.2 apply for any deviation from PCDH rules.

Issue sheets must be recorded electronically and archived using the IO issue tracking tools at least.

A severity level value must be assigned to each issue reported as follows:

- **Severity Level 1:** major issue that must be fixed before shipping of the procured equipment to the ITER site.
- **Severity Level 2:** an issue that may be fixed on the ITER site before the system commissioning.
- **Severity Level 3:** minor issue acceptable for I&C integration to CENTRAL I&C infrastructure: may be fixed later but before the final acceptance by IO.

The issue sheet will monitor the progress and resolution of the issue. The life cycle of the issue sheet must have at least:

- **Open:** the issue sheet has been created and contains the full description of the issue
- **Fixed:** the root causes of the issue have been identified and the corresponding fix has been delivered
- **Validated:** the fix has been successfully re-tested, including non-regression tests. If the delivered fix doesn't pass the validation, the issue sheet status moves back to Open.

The Issue Sheet must record all the information related to the investigation of the root cause of the issue and all the remedial actions throughout its lifecycle.

6.2 Acceptance process

IO and DA representatives (DA for in-kind procurements) attend the FAT and SAT for campaigns C2, C3 and C4.

An acceptance test plan will be issued by the I&C SU. A template for the test plan and report covering the scope of I&C is available at: FAT-SAT plan and report for I&C (ATCLA4)

The result of the execution of the FAT and SAT plans for I&C is recorded in the FAT and SAT reports (PCDH D50 and D65 respectively), which indicate:

- ✓ The result of each test campaign part of the test plan:
  - **Fully Passed:** the campaign is complete and all the scenarios have been successfully executed.
  - **Partially Passed:** the campaign is complete but some of the scenarios failed.
  - **Blocked:** an issue encountered in a certain scenario prevents the completion of the campaign.
  - **Not Executed:** the campaign has not yet been executed.
- ✓ The reference to any issue sheets raised for each campaign.

When an issue of Severity Level 1 is encountered, the IO and DA representatives (for in-kind procurement) may decide either to stop the acceptance process (if they consider that the consequences of the defect are either too important or that the remaining tests would not be valid) or to continue it.

Issues of Level 2 and Level 3 do not stop the acceptance process.

If the number of issues encountered requires the delivery of a new release to fix them, IO and DA representatives and the supplier have to define and agree on the following:

- ✓ The set of tests or checks to be re-executed for validating the fix. The aim is to demonstrate that the fix does actually solve the issues it is supposed to address.

- ✓ The list of test scenarios to be re-executed as part of the non-regression testing, based on an analysis of the potential impact of the fix on other parts of the system. The aim is to demonstrate that the fix does not compromise the other parts of the system.

The progress of factory acceptance can be assessed by means of indicators maintained in the FAT and SAT reports:

- ✓ Campaigns executed.
- ✓ Campaigns passed/partially passed/blocked.
- ✓ Campaigns not yet executed.

6.3 Acceptance criteria

Acceptance criteria should be globally defined at project level by IO in order to ensure consistency across all the acceptance-related activities and project milestones, including the FAT.

In the interim, the following criteria can be proposed for FAT and SAT acceptance for I&C:

- ✓ Test campaign execution rate: this is the rate of campaigns which have been fully executed. A campaign is considered fully executed when all its procedures have been executed, i.e. the campaign execution result is either “Fully Passed” or “Partially Passed”.
- ✓ Number of issues with Severity Level 1.
- ✓ Number of issues with Severity Level 2.
- ✓ Number of issues with Severity Level 3.

The acceptance is validated when:

- ✓ **Test campaign execution rate is 100%**
- ✓ **All issues with Severity Level 1 have been fixed and validated for FAT.**
- ✓ **All issues with Severity Level 2 have been fixed and validated for SAT.**

The acceptance might be provisionally validated when:

- ✓ The campaign execution rate is 100%
- ✓ All issues with Severity Level 1 and all unacceptable issues with Severity Level 2 have been fixed and validated.
- ✓ All remaining Severity Level 2 issues are such that they do not make the use of the system unreasonable in an operational mode.

Issues of level 3 cannot lead to a refusal of acceptance.

7 Campaign details for FAT and SAT

7.1 The PCDH requirement mapping matrix

The PCDH mapping matrix of requirements provides a mapping between PCDH requirements and:

- ✓ The associated severity level for acceptance.
- ✓ Whether any test is required for checking the requirement.
- ✓ In which of the C1, C2, C3, and C4 campaigns the requirement should be checked.
- ✓ Where the check must be performed: FAT or SAT. An "X" indicates if the check is mandatory, an "O" if optional or acceptable. The procurement configuration is also considered at this stage, see Section 2.3 for further details.

The PCDH requirement is identified by its PCDH section number, title, requirement/deliverable identifier and description.

Table 1 provides an illustration of this mapping: the PCDH-R55 requirement is verified in the scope of the C4 campaign for I&C equipment procured with configurations #1 and #2 only. Therefore, this requirement will be checked during SAT for procurement configuration #3. In addition a test is required and the severity level is assigned to 1.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant system I&C Design Philosophy												
Plant System I&C Life Cycle												
Specification												
Plant System I&C Architecture												
Mini-CODAC												
4.2.1	Mini-CODAC	[R52]	1	Mini-CODAC shall be used for FAT as a substitute for the CODAC System.	x				x	none	X	O
		[R53]		OSI layer 2 switch is the only plant system I&C component that has a physical interface with Mini-CODAC.						Design requirement checked during the design phase	-	-
		[R54]		The physical interface of the plant operation network between Mini-CODAC and the plant system I&C shall be a conventional Gigabit Ethernet connection.						Design requirement checked during the design phase	-	-
		[R55]	1	The functional interface of the plant system I&C shall be tested with the Mini-CODAC.	x				x	none	X	O
		[R56]	1	The software components delivered with the plant system I&C that will be integrated into the CODAC System shall be tested with Mini-CODAC.	x				x	Target standard I&C equipment only	X	O

Table 1: Illustration of the mapping matrix. The complete matrix is given in chapter 8.

7.2 Rules applicable to all campaigns

The rules mentioned in the Table 2 address the management of deviations from PCDH requirements and are applicable to the complete I&C system life-cycle, including FAT and SAT. See PCDH for further details.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant system I&C Design Philosophy												
Plant System I&C Life Cycle												
Specification												
Interface Specification between Plant System I&C and Central I&C systems												
Interlock I&C Specification												
Safety I&C Specification												
Deviations Policy												
8	Deviations Policy	[R281]		Requests for deviations from and non-conformance with the requirements of the ITER Plant Control Design Handbook shall be made to the IO in writing following the procedures detailed in [RD11], [RD19] and [RD12]. The decision on the acceptance of the non-conformance report shall be made by the plant system central I&C responsible officer of the IO.						Design requirement checked during the design phase	-	-
		[R282]	1	Any I&C equipment which is non-complaint to the PCDH requirements shall be subject to the Non-Conformance Report Process described in the ITER Deviations and Non-Conformances [RD12] and [RD19]. Every non-conformance shall be accompanied by an obsolescence management plan as suggested by IEC 62402.		x	x	x	x	Apply to all campaigns	X	O
		[R283]	1	The plant system responsible officer (and plant system I&C supplier, if appropriate) has to provide and pay for special integration and additional maintenance including spare parts for non standard equipment.		x	x	x	x	Apply to all campaigns	X	X
		[R284]	1	A deviation request shall include an alternative proposal including a justification of why I&C specifications in this document or procurement document were not followed, and a list of attachments which support the justification.		x	x	x	x	Apply to all campaigns	X	O
		[R285]	1	A non-conformance report shall include the original requirement, a description of the non-conformance, proposed remedial action, and a list of attachments which support the proposed remedial action.		x	x	x	x	Apply to all campaigns	X	O
		[R286]	1	If the plant system responsible officer (and plant system I&C supplier, if appropriate) discovers that he had misinterpreted these technical specifications after signing the PA, this shall not be accepted as an excuse for deviations from it.		x	x	x	x	Apply to all campaigns	X	O
		[R287]	1	During execution of the procurement, all deviations from the technical specifications shall be reviewed and finally approved by IO.		x	x	x	x	Apply to all campaigns	X	O
		[R288]	1	IO shall consider the proposal on an expedited basis.		x	x	x	x	Apply to all campaigns	X	O
		[R289]	1	IO reserves rights to reject or accept such proposals.		x	x	x	x	Apply to all campaigns	X	O

Table 2: PCDH rules applicable to all campaigns and types of procured equipment for FAT and SAT

7.3 Campaign C1: I&C documentation

Campaign purpose: This campaign checks that PCDH rules applicable to the documents delivered in the scope of a procurement are met. These documents are identified in PCDH as deliverables D31, D32, D34, D38, D39, D40, D41, D42, D43, D44, D48, D60 and D71. They are all provided by the I&C SU.

Campaign scope: The relevant deliverables are identified in the PCDH as:

- ✓ **Deliverable D31:** is the relevant set of functional specifications of the I&C system. D31 covers the detailed description of the active controls and the monitoring of the plant system function. This deliverable has a free format and is checked by the PS I&C RO for completeness with respect to other technical specifications. D31 covers all of the plant system functions including conventional, interlock and safety functions in the scope of the PA and must be delivered for all configurations (#1 to #3).
- ✓ **Deliverable D32:** is the set of SW documents and files produced with the engineering tools defined by IO in Section 4.4 of PCDH. D32 is checked by the PS I&C RO with the support of the CSD for compliance with the technical specifications and with PCDH requirements. D32 must be delivered for I&C equipment with configurations #1 and #2.
- ✓ **Deliverable D34:** is the set of technical documents for specifying the internal configuration and cabling of cubicles. Satellite document [SD24] is a guideline unless something falls within the scope of IO cabling rules [RD2]. This deliverable has a free format and is checked by the PS I&C RO against the technical specifications, against the cabling rules [RD2] and any additional requirement related to the cubicle installation and environmental constraints (see [RD4]). D34 must be delivered for I&C equipment with configurations #1 and #2. The rules related to the selection of the hardware are checked in scope of campaign C2. D34 must include a bill of materials for the I&C cubicle parts.
- ✓ **Deliverable D38:** is the set of cabling drawings to be provided for cabling the I&C cubicles to the plant system equipment and to CENTRAL I&C infrastructure. IO cabling rules apply [RD2] to D38; it is checked by the PS I&C RO for completeness and compliance with [RD2].
- ✓ **Deliverable D39:** is the procedure for installation of all hardware and software packages provided. The procedure must be detailed enough to be used in the scope of campaign C4 to check the capability of IO to replace any I&C hardware parts and reinstall any software package. D39 is checked against a CSD template for completeness in the scope of the campaign C1. (template is TBD).
- ✓ **Deliverable D40:** comprises all original documents provided by I&C equipment suppliers concerning mounting, cabling, configuring, operating and maintaining any I&C equipment. A non-exhaustive list of I&C equipment is: I&C controllers and parts of controllers (chassis, boards,..), signal interfaces and power supplies, network interfaces and switches, cubicles and accessories including cubicle heating, ventilation and air conditioning (HVAC) and monitoring systems. It is assumed a bill of materials is provided by the procurement supplier; the PS I&C RO checks the completeness of D40 with respect to the bill of materials.
- ✓ **Deliverable D41:** in addition to the cabling diagrams used for on-site installation, D41 is the set of drawings showing the complete path of I&C signals from the sensors/actuators up to the signal interfaces of the I&C controllers. The path is through junction boxes, signal conditioning devices, terminal blocks and other power supplies involved in the generation of the signals. The purpose is to facilitate signal failure analysis by providing a complete picture of the signal route for each I&C signal D41 is checked by the PS I&C RO.
- ✓ **Deliverable D42:** concerns the calibration factors for the sensors and the actuators used in the I&C controllers. These calibration factors are part of the plant system configuration data. See PCDH and SDD for details. D42 may be part of D40 and is checked by the PS I&C RO.
- ✓ **Deliverable D43:** D43 is an extension of D40 and concerns the documents issued during the manufacturing phase by the I&C SU specifying the installation, operation and maintenance. Therefore, these documents are procurement-specific and mainly cover procedures and user

manuals. They are checked by the PS I&C RO with the support of CSD for everything linked to CENTRAL I&C interfaces and services.

- ✓ **Deliverables D44 and D71:** concern the short term (D44) and long term maintenance and obsolescence management (D71) for any I&C equipment not compliant with PCDH standards. It is assumed that CSD will manage obsolescence issues related to PCDH standards for HW and SW. Therefore the I&C SU must propose a solution or at least a roadmap to resolve the obsolescence problem for any non-compliant equipment during its life-cycle on ITER plant. D44 and D71 are checked by the PS I&C RO with support from CSD.
- ✓ **Deliverable D48:** these are the certificates of conformity concerning regulations applicable at ITER site for the I&C equipment. D48 checking may be incorporated with checking of any other procurement equipment (non I&C included).

The PCDH rules applicable to campaign C1 are the general IO rules for documents. In addition, rules R18, R20, R21, R22, R43, R44, R45 and R46 for document management and quality apply, see Table 3 for details.

The deliverable documents mentioned above can be merged together for optimization of delivery purposes. If so, these documents must include a mapping table between PCDH deliverables and sections and the delivered documents.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant system I&C Design Philosophy												
Plant System I&C Life Cycle												
Development												
Management												
3.4.1	I&C Deliverables Management	[R18]	2	Outputs or deliverables shall be identified and managed to ensure that IO and involved DAs know that they have the correct version and shall be advised of any changes and/or deficiencies. Each output shall be recorded with at least the output identifier/name, the type, the description, the current version and the status (not built, built, reviewed and approved).		x				Targets all life cycle deliverables	X	O
		[R20]	2	All deliverables shall be traceable to their parent output as well as to their relevant specification and design item.		x				Targets all life cycle doc deliverables	X	O
		[R21]	2	All deliverables in electronic format shall be backed up after the acceptance phase in order to secure a functional restore state.		x				Targets all life cycle doc deliverables	X	O
		[R22]	1	All deliverables shall be approved by IO.		x				Targets all life cycle doc deliverables	X	O
I&C manufacture												
3.4.3	I&C manufacture	[D31]	1	Detailed descriptions (text documents including structured lists in self-description data format) of: Process control for any plant system operation state. Process failure detection and strategy for process control. I/O treatments. Data exchanges required for slow and fast controls. Feedback controls. HMI, alarms and events. Software architecture for these items with identification of related software modules and data exchange links.		x				Part of check under PS RO scope	X	O
		[D32]	1	Full software and configuration documentation as generated by the ITER IO prescribed engineering tools.		x				Targets IO standard controllers	X	O
		[D34]	1	Every document required for cubicle mounting, air conditioning, assembly, external and internal wiring, earthing and powering. Inventory of any equipment or component used for cubicle manufacturing (including I&C equipment), with supplier identification and a supplier procurement reference		x				SCC and LCC	X	O
		[D38]	1	Cabling documents for cubicle connection with I/O cabinets, I&C Networks, earth and power supplies.		x				Including I/O cabling to all I&C equipment	X	O
		[D39]	1	Procedure of installation, configuration, starting up and software and hardware completeness checks for the plant system I&C in particular for plant system specific components (non- standard components).	x	x			x	none	X	O
		[D40]	1	Original technical documentation for each piece of equipment or component (including software) used to manufacture the systems in an I&C cubicle.		x				none	X	O
		[D41]	1	Schematic diagrams of the full signal path from the sensors/actuators to the I/O boards of the controllers including powering and conditioning, with identification of test points for fault analysis or calibration and identification of the terminal blocks. Trouble shooting procedures and functions.		x				none	X	O
		[D42]	1	Calibration factors for each sensor-actuator-conditioner-I/O board and procedures for re-calibration of these components.		x				none	X	O
		[D43]	1	Technical documents, manuals and procedures required for maintenance of any I&C component.		x				none	X	O
		[D44]	1	Maintenance plan: detailed warranty and/or maintenance periods and their possible extensions, licensing requirements.		x				none	X	O
		[D48]	1	Certificates of conformity for I&C procurement to any regulation applicable on ITER site and proof of compliance to ITER I&C standards.		x				none	X	O
I&C Factory Acceptance Tests												
3.4.4	I&C Factory Acceptance Tests	[R25]	1	The results of FAT shall be recorded and retained in the lifetime records of the ITER plant. Any failures during FAT shall be investigated and the cause and rectification of the failure documented in the FAT report. A complete bug report (problems and fixes) must be provided and maintained during all life-cycle phases.		x				none	X	O
I&C Acceptance Tests												
I&C Obsolescence Management												
3.4.9	I&C Obsolescence Management	[D71]	2	A proactive management plan for obsolescence describing the strategies for identification and mitigation of the effects of obsolescence throughout all stages of I&C life cycle		x				Targets the non standard equipment	X	O
I&C Documentation												
3.4.11	I&C Documentation	[R43]	1	All documentation shall be in the English language.		x				none	X	O
		[R44]	2	All documentation shall be available in editable electronic format (PDF, Open Document XML format or Microsoft Word) and in an online version which is accessible using IO product lifecycle management system.		x				none	X	O
		[R45]	2	All documentation shall be under version control.		x				none	X	O
		[R46]	2	For every item (including 3rd party and COTS) the original documentation shall be delivered.		x				none	X	O

Table 3: Deliverables and rules for campaign C1

7.4 Campaign C2: I&C hardware

Campaign purpose: This campaign checks the PCDH rules applicable to the I&C hardware (HW) are met. No I&C cubicle powering or tests are required for C2 campaign. The HW deliverable acceptance is granted subject to a limited number of PCDH rules, assuming other relevant rules have been checked during design and manufacture phases.

Campaign scope: The C2 scope is the HW delivered in scope of the PA: D18, D19 and D74:

- ✓ **Deliverable D18**: it is assumed all I&C equipment as defined in PCDH and in the scope of the PA will be installed in cubicles and these cubicles will be compliant with the IO standards defined in PCDH, see section 4.5.3. Hence, D18 is the set of I&C cubicles which are ready to be integrated in the plant system I&C architecture. The detailed HW configuration is given in D34. No I&C cubicle is expected for procured equipment with configuration #3. D18 will be checked by the PS I&C RO.
- ✓ **Deliverable D19:** comprises the spare parts for I&C maintenance. The quantity and scope of the spare parts is normally specified in Annex B of the PA. D19 will be checked by the PS I&C RO against what is specified in Annex B of the PA.
- ✓ **Deliverable D74:** gathers all of the hardware tools required to maintain non-standard I&C equipment. Only R24 applies to this deliverable; the scope is plant system specific and must be determined on a case by case basis. D74 will be checked by the PS I&C RO.

The PCDH rules to apply on HW deliverables are mentioned in Table 4. Additional details are given below:

I&C equipment:

- ✓ Check the compliance with IO standards of the equipment delivered using product catalogues [SD12] to [SD15]. See rules R132, R133, and R157.
- ✓ Check the naming of I&C equipment: see rules R65 and R66. The cubicle enclosure, the controller chassis and remote IO chassis (slow and fast controllers), the PSH and switches and all external cables connected to the cubicles must be labelled and named accordingly. The guidelines for cubicle tagging are given in [SD24] and for cable tagging in [RD2].
- ✓ Check the conformity of the I&C HW configuration with the rules related to reserved slots and load ratios.
  - Rules R105 and R107 must be checked for each controller configuration (slow and fast).
  - Rule R106 must be checked against the cubicle HW configuration for the space remaining available for HW extensions.

Physical interface with the plant system equipment (signals):

- ✓ Cables and cabling, (Rule R159): Check the compliance of the cabling interface and the cubicle cable entries with the cabling rules of [RD2].

Physical interface with IO infrastructure (at the limit of the scope of PCDH):

- ✓ Mechanical interface with the building: Check the cubicle fixings against what was specified by IO.
- ✓ Power supply: check that the power supply configuration is as specified in rule R199.
- ✓ Environmental condition compliance (rule R179): must be considered at design phase but may be assessed again at the installation phase.
- ✓ Cubicle configuration with respect to access for maintenance (rule R180): this point is related to the configuration of the doors. Check that he cubicle door configuration and access to internal equipment conforms with what was specified by IO.
- ✓ Cubicle cooling: if some connection to an external cooling device is required, check the configuration of the interface. If not, check the configuration of the air inlet and outlet with respect to what was specified by IO.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant System I&C Life Cycle												
I&C manufacture												
3.4.3	I&C manufacture	[D18]	1	I&C cubicles with internal wiring and all internal I&C equipment			x			SCC and LCC	X	O
		[D19]	2	I&C spare parts list with appropriate specifications of storage space and conditions			x			Topic sometimes specifically discussed for the whole procurement	X	O
		[D74]	1	Tools required for maintenance of any I&C component.			x	x		none	X	O
I&C Factory Acceptance Tests												
3.4.4	I&C Factory Acceptance Tests	[R23]	2	For every test (unit testing; system and integration testing; acceptance testing) the version of the equipment being tested, the version of the test specifications being used and, for acceptance testing, the version of the design specification being tested against, shall be recorded.			x	x		Targets all configurable I&C equipment	X	X
		[R24]	1	The procurement I&C supplier shall provide all necessary hardware and software tools and configuration files for FAT			x	x		Includes the tools used to configure and maintain the sensors and actuators	X	O
Specification												
Plant System I&C Architecture												
I&C Naming Conventions												
4.3.1	Components Naming Conventions	[R65]	1	A convention for uniquely identifying parts and components for ITER is defined in the ITER Numbering System for Parts/Components, see [RD3]. This naming convention is applicable to any component of the plant system I&C			x			none	X	O
		[R66]	1	The component naming convention, as defined in the previous section, applies to the component identifier.			x			none	X	O
Non-functional Requirements												
4.4.2	Non-functional Requirements	[R105]	1	Additional reserve slots (not equipped) per backplane type shall be more than 20%.			x			none	X	O
		[R106]	1	Additional reserve I/O channels (not equipped) per type shall be more than 20%.			x			none	X	O
		[R107]	1	Additional reserve I/O channels (equipped) per type shall be more than 5%.			x			none	X	O
Plant System I&C Hardware Specification												
Plant System Slow Controller												
4.5.1	Plant System Slow Controller	[R132]	1	Slow controllers shall use the Siemens Simatic S7-300 or S7-400 ranges.			x			To be checked at FAT but at earlier stage for risk mitigation	X	O
Plant System Fast Controller												
4.5.2	Plant System Fast Controller	[R133]	1	Fast controllers shall be based on PCI Express I/O bus system.			x			To be checked at FAT but at earlier stage for risk mitigation	X	O
I&C Cubicles												
4.5.3	I&C Cubicles	[R157]	2	The I&C cubicles shall be equipped with a monitoring system for doors, temperature and cooling monitoring and the monitoring system shall be interfaced to the plant system I&C.	x		x		x	To be checked at FAT but at earlier stage for risk mitigation	X	O
I&C Signal Cabling Rules												
4.5.4	I&C Signal Cabling Rules	[R159]	2	The ITER cabling rules apply to signal cabing			x			To be checked at FAT but at earlier stage for risk mitigation	X	O
Bondering - Powering												
4.5.6	Bondering - Powering	[R199]	1	Plant system I&C shall use Class-IV power supply as defined in EDH, [RD4] single phase for conventional cubicles. The PIS and PSS will use Class II – IP and may be backed up by Class IV, see chapter 6 and 7 of that document			x			Integration requirement to be checked at SAT	-	X
Environment, Location and Volume Management												
4.5.7	Environment, Location and Volume Management	[R179]	1	I&C equipment shall comply with the environment conditions of the location at which they will be installed. If not a suitable protection shall be defined for the I&C equipment. Such conditions concern magnetic fields, neutron flux, electromagnetic radiation, vibration coming from other equipment or seismic event, temperature and humidity			x			Integration requirement to be checked at SAT	-	X
		[R180]	2	Access to the instrumentation, cubicles and junction boxes shall be sufficient to allow installation of testing and calibration equipment			x			Integration requirement to be checked at SAT	-	X

Table 4: Deliverables and rules for campaign C2

7.5 Campaign C3: configuration data and software

Campaign purpose: This campaign checks that the PCDH rules applicable to I&C software (SW) packages are met. No SW deliverable tests are required for the C3 campaign; the SW deliverable acceptance is granted subject to a limited number of PCDH rules, assuming other relevant rules have been checked during design and manufacture phases.

Campaign scope: The relevant deliverables are identified in the PCDH as D20, D26, D72 and D74; they are all provided by the I&C SU:

- ✓ **Deliverable D20:** comprises the Self-Description Data as described in PCDH Section 4.4.6 and [SD4]. The SDD includes references to signals, variable and process variables (PV). The content of D20 is checked against the configuration and naming conventions for I&C components, signals and variables, network configurations, see the associated rules in Section 4.3.1 of PCDH. D20 must be delivered using the dedicated CODAC SDD editor. D20 includes the implementation of COS and the mapping of COS with the specific PSOS. D20 is checked by the the PS I&C RO with the support of IO CSD.
- ✓ **Deliverable D26:** comprises the HMI configuration of the mini-CODAC, archiving and alarm handling required for future operation using CENTRAL I&C systems and infrastructure. In addition D26 includes what is required to perform the SAT and FAT as described in this document, see Chapters 3 and 5. D26 must be delivered using the dedicated tool kit of the core CODAC version in use at FAT date. D26 is checked by the the PS I&C RO with the support of IO CSD.
- ✓ **Deliverable D72:** gathers all user software specifically developed for the I&C for active control, monitoring, simulation and testing purposes (FAT, SAT, any other tests). D72 includes all configuration data files used to configure the I&C equipment installed in the I&C cubicles but also the sensors and actuators. D72 does not include the Self Description Data identified as deliverable D20 in the PCDH. D72 will be checked by the PS I&C RO with the support of the IO CSD.
- ✓ **Deliverable D74:** comprises all of software tools required to maintain non-standard I&C equipment. Only R24 applies to this deliverable; the scope is plant system specific and must be determined on a case by case basis. D39 will be checked by the PS I&C RO.

The PCDH rules to apply to SW deliverables are listed in Table 5. Additional details are given below:

SW storage:

- ✓ SDD data, deliverable D20: use the IO SDD repository, see core CODAC user manual for the procedure to apply.
- ✓ Mini-CODAC configuration, deliverables D26 and D72: use the IO SVN repository at https://svnpub.iter.org/codac/iter/codac/**icdev**/units/, see core CODAC user manual for the procedure to apply.

SW validation:

- ✓ **SDD:** The SDD data must pass the integrity, completeness and compliance validation of the SDD editor.
- ✓ **PLC:**
  - R297 will be checked by compilation of the PLC user software on a STEP7 engineering station configured with the STEP7 version specified in PCDH.
  - The user software architecture of the PLCs will be checked against the PLC software engineering handbook [SD10].
- ✓ **Fast controllers:**
  - R111, R112 and R118 for EPICS version and data communication apply.
  - R113 applies to the OS version.
  - FPGA: R119 applies.
- ✓ **PSH - mini CODAC**: R155 applies for the core system version.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement description, refer to the approved document for details	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant System I&C Life Cycle												
I&C manufacture												
3.4.3	I&C manufacture	[D72]	1	Source code of any software developed for the plant system I&C for operation, factory acceptance test, site acceptance test, integrated commissioning and maintenance, in the scope of the PA. Configuration data for any plant system I&C controller to be downloaded.				x		Targets mainly IO standard controllers, to be discussed on a case by case basis for specific embedded controllers	X	O
		[D20]	1	Plant system I&C self-description data				x		Using IO tools	X	O
		[D26]	1	Mini-CODAC: configuration developed in Mini-CODAC environment required for factory acceptance test, site acceptance test and integrated operation				x		For FAT, SAT and plasma operation	X	O
		[D74]	1	Tools required for maintenance of any I&C component.			x	x		none	X	O
I&C Factory Acceptance Tests												
3.4.4	I&C Factory Acceptance Tests	[R23]	2	For every test (unit testing; system and integration testing; acceptance testing) the version of the equipment being tested, the version of the test specifications being used and, for acceptance testing, the version of the design specification being tested against, shall be recorded.			x	x		Targets all configurable I&C equipment	X	X
		[R24]	1	The procurement I&C supplier shall provide all necessary hardware and software tools and configuration files for FAT			x	x		Includes the tools used to configure and maintain the sensors and actuators	X	O
Specification												
I&C Naming Conventions												
4.3.1	Components Naming Conventions	[R69]	1	The following naming convention [SD1] applies to I&C signals and process variables (PVs).				x		none	X	O
		[R68]	1	The plant system function identifier shall be based upon a Control Breakdown Structure (CBS) and satisfy the following naming convention:				x		none	X	O
		[R153]	1	By analogy with the signals, the convention for naming variables is				x		none	X	O
		[R154]	1	The variable identifier is a free string of 16 characters maximum VV…VV, provided the full name including the function identifier is unique within the whole ITER plant				x		none	X	O
PS I&C SW specifications												
Software Infrastructure												
4.4.3	Software Infrastructure	[R155]	1	CODAC core system version 3.0 or above shall be used on Mini-CODAC and PSH				x		none	X	O
		[R111]	1	EPICS version R3.14.12 shall be used for PS fast controllers.				x		none	X	O
Operating Systems												
4.4.4	Operating Systems	[R113]	1	The Operating System of the PS fast controllers is Red Hat Linux 6.1 x86_64, desktop with workstation option.				x		none	X	O
Programming Languages and Tools												
		[R115]	2	The software versioning control tool shall be Subversion.				x		none	X	O
		[R297]	1	PLCs shall be programmed with the engineering software STEP7 v5.5 or above.				x		none	X	O
		[R118]	1	Fast controllers shall be programmed using the CODAC Core System distribution version 3.0 or above.				x		none	X	O
		[R119]	1	The core CODAC supports following development tool chains:				x		none	X	O

Table 5: Deliverables and rules for campaign C3

7.6 Campaign C4: I&C functional requirements

Campaign purpose: This campaign aims to check that the PCDH rules related to functional requirements of the plant system I&C systems are met. A prerequisite of the C4 campaign is the completion of campaigns C1 to C3 since the deliverables associated with them are required for C4 execution.

Campaign scope: The relevant deliverable identified in PCDH for the installation of the plant system I&C is D39. In addition to D39 check, the tests of the functional interfaces between Central I&C systems and the equipment are performed.

The tests related to the active control of the plant system equipment are beyond the scope of this document. These tests may be performed after the C4 campaign at the request of the procurement RO. In such a case they will be specified and executed under the responsibility of the procurement RO.

The PCDH rules to be checked in the scope of C4 are mentioned in the Table 6. These rules will be checked by the PS I&C RO with the support of the IO CSD and will comprise:

- **Deliverable D39 checking:** D39 is the procedure for installation of all hardware and software packages provided in the scope of the PA. The procedure D39 is checked against an IO template for completeness in the scope of the campaign C1 and is checked for HW and SW installation suitability in the scope of the C4 campaign.
- **Functional requirements checking:** the functional interface with central I&C systems is specified in the plant system interface sheets for PBS45 to PBS48 (CODAC, Central Interlock, Plant Control System and Central Safety System). PCDH Section 5.2 provides the rules to apply. It is assumed that the I&C system is configured with a mini-CODAC and PSH computers for testing of the functional interfaces with CENTRAL I&C in order to comply with R52, R55 and R56 rules. As a consequence, the mini-CODAC must be configured to implement all of the CENTRAL I&C functions mentioned in the interface sheets. With these boundary conditions, the functional interface with CENTRAL I&C systems is checked as follows:
  - **State data, simple commands and configuration data over PON:** This tests signal connectivity from signal interfaces in the I&C cubicle up to the central I&C operator interfaces. During these tests, the active controls are disabled at controller level to avoid any un-expected automatic action which could potentially disturb the tests or even damage the plant system. The test procedure is performed as follows:
    - Inputs (digital and analogue): For each controller interface board, the input signals are simulated at the signal terminal block level and the continuity of the data processing including any data treatment up to the mini-CODAC display is checked. The procedure to apply is TBD.
    - Outputs (digital and analogue) and internal variables: The associated variables are simulated/forced in the controller. The procedure to apply is TBD.
    - Health monitoring data**:** The procedure to apply is TBD.
    - COS management: The procedure to apply is TBD.
  - **Time synchronization over TCN:** The procedure to apply is TBD.
  - **Data over SDN:** The procedure to apply is TBD.
  - **Data over DAN:** The procedure to apply is TBD.
  - **Data over AVN:** The procedure to apply is TBD.
  - **Data over CIN:** The procedure to apply is TBD.
  - **Data over CSN:** The procedure to apply is TBD.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant System I&C Life Cycle												
I&C manufacture												
3.4.3	I&C manufacture	[D39]	1	Procedure of installation, configuration, starting up and software and hardware completeness checks for the plant system I&C in particular for plant system specific components (non- standard components).	x	x			x	none	X	O
I&C Acceptance Tests												
3.4.6	I&C Acceptance Tests	[R30]	1	The results of SAT shall be recorded and retained in the lifetime records of the ITER plant. Any failures during SAT shall be investigated and the cause and rectification of the failure documented in the SAT report					x		-	X
		[R371]	1	SAT is performed with Mini-CODAC. Mini-CODAC may be complemented by specific tools for the PIS and PSS.	x				x		-	X
		[R372]	1	Data links with Mini-CODAC not tested during FAT shall be tested during SAT. See [SD6] for details for FAT.	x				x		-	X
		[R373]	1	For performance test purpose, the plant system I&C shall be tested under a scenario and acceptance criteria provided by the ITER plant system RO. This scenario shall include the individual tests of every plant system I&C function with the real process connected to the plant system I&C and the test of the plant system as a complete autonomous system, without any interaction with Central I&C Systems	x				x	Check under PS RO responsibility for scope and procedure	-	X
Specification												
Plant System I&C Architecture												
Mini-CODAC												
4.2.1	Mini-CODAC	[R52]	1	Mini-CODAC shall be used for FAT as a substitute for the CODAC System.	x				x	none	X	O
		[R55]	1	The functional interface of the plant system I&C shall be tested with the Mini-CODAC.	x				x	none	X	O
		[R56]	1	The software components delivered with the plant system I&C that will be integrated into the CODAC System shall be tested with Mini-CODAC.	x				x	Target standard I&C equipment only	X	O
PS I&C SW specifications												
Functional requirements												
4.4.1	Functional requirements	[R77]	2	The plant system I&C shall be able to autonomously maintain safe operation of the plant system in case of loss of central I&C systems or I&C networks (not applicable to PSS).	x				x	Functional requirement to be checked at SAT	-	X
		[R78]	2	The start-up strategy shall take into account the current state of the process and the presence/absence of the CODAC system (not applicable to PSS).	x				x	Functional requirement to be checked at SAT	-	X
I&C Cubicles												
4.5.3	I&C Cubicles	[R157]	2	The I&C cubicles shall be equipped with a monitoring system for doors, temperature and cooling monitoring and the monitoring system shall be interfaced to the plant system I&C.	x		x		x	To be checked at FAT but at earlier stage for risk mitigation	X	O
Interlock I&C Specification												
6.2	Interlock I&C Architecture	[R332]	1	The functional interface of the plant system I&C shall be tested with the Mini-CODAC.					x	none	X	O

Table 6: Deliverables and rules for campaign C4

8 PCDH rules not considered during FAT and SAT

The following rules must be checked during the design and manufacturing phases: They are assumed to have been met for the FAT and therefore will not be considered in the definition of FAT and SAT scenarios and any acceptance criteria.

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant system I&C Design Philosophy												
Plant system I&C mandatory functional requirements												
2.3	Plant system I&C mandatory functional requirements	[R1]		Plant system I&C shall perform control of the plant system under the authority of CODAC during any operating state.						Design requirement checked during the design phase	-	-
		[R2]		Plant system I&C shall comply with project-wide supervisory control functions and central data handling functions (i.e. archiving, monitoring, logging and visualization) provided by CODAC System.						Design requirement checked during the design phase	-	-
		[R3]		Plant system I&C shall make available all data acquired from sensors/actuators, with a time stamp, to Central I&C Systems for analysis, archiving, logging, monitoring and visualization. The principle of "no hidden data" is applicable for all plant systems I&C; there shall be no permanent local storage of data.						Design requirement checked during the design phase	-	-
		[R4]		Plant system I&C shall provide status information for common operating states, plant system operating state, alarm conditions, trip conditions and corrective actions, control system set points and power supply status information that is required to operate the plant system I&C from Main Control Room (MCR).						Design requirement checked during the design phase	-	-
		[R5]		Plant system I&C shall be designed to be configurable from MCR using its self-description data.						Design requirement checked during the design phase	-	-
		[R10]		Plant system I&C shall be operated centrally from MCR.						Design requirement checked during the design phase	-	-
		[R11]		Permanent local control rooms are forbidden. There are two exceptions to this rule; remote handling and tritium plant.						Design requirement checked during the design phase	-	-
		[R12]		Plant system I&C shall use Mini-CODAC as a tool for plant system software development support, integration, factory acceptance test and site acceptance test. Mini-CODAC will be complemented by certified tools for PIS and PSS.						Design requirement checked during the design phase	-	-
		[R15]		Plant system I&C shall have built-in absolute-limit protection to prevent local control and central control errors. Time critical devices shall have built-in time-outs to ensure correct operation in case of Central I&C Systems failure.						Check under PS RO responsibility for scope and procedure	-	-
Plant System I&C Life Cycle												
Development												
I&C Obsolescence Management												
3.4.9	I&C Obsolescence Management	[R291]		The latest PCDH version available shall be applicable when the PA is signed						Operation/maintenance phase relevant only	-	-
		[R37]		IO is committed to support old versions of PCDH standards, including the obsolescence management of those standards.						Operation/maintenance phase relevant only	-	-
		[R38]		Every new I&C equipment shall be documented in the same way as was required for the initial procurement.						Operation/maintenance phase relevant only	-	-
		[R40]		Training for operation and maintenance teams shall be included in the process of replacement, if required.						Operation/maintenance phase relevant only	-	-
		[R41]		The plant system ROs shall define requirements for their plant system I&C backup and storage by successive evolutions and the strategy to adopt in case of obsolescence.						Check under PS RO responsibility for scope and procedure	-	-
Specification												
Plant System I&C Architecture												
Mini-CODAC												
4.2.1	Mini-CODAC	[R53]		OSI layer 2 switch is the only plant system I&C component that has a physical interface with Mini-CODAC.						Design requirement checked during the design phase	-	-
		[R54]		The physical interface of the plant operation network between Mini-CODAC and the plant system I&C shall be a conventional Gigabit Ethernet connection.						Design requirement checked during the design phase	-	-
Plant System Host												
4.2.2	Plant System Host	[R59]		Each plant system I&C shall have one and only one PSH.						none	-	-
		[R60]		The PSH shall be connected to the OSI layer 2 switch.						Design requirement checked during the design phase	-	-
		[R61]		The PSH shall be integrated into the plant system I&C.						Design requirement checked during the design phase	-	-
		[R62]		5U [TBC] in a 19" rack and 500W power supply shall be allocated for the PSH in one of the plant system I&C cubicles.						Design requirement checked during the design phase	-	-
		[R63]		The interface between the PSH and the plant system controllers shall be Ethernet.						Design requirement checked during the design phase	-	-
		[R64]		The PSH shall be configured by the plant system I&C designers using the software kit supplied by IO.						Design requirement checked during the design phase	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement description, refer to the approved document for details	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Plant system I&C Design Philosophy												
Specification												
I&C Naming Conventions												
4.3.1	Components Naming Conventions	[R67]		The signal identifier shall satisfy the following naming convention: The signal identifier is made of three parts:						none	-	-
PS I&C SW specifications												
Functional requirements												
4.4.1	Functional requirements	[R70]		The plant system I&C shall implement the following functions:						Design requirement checked during the design phase	-	-
		[R71]		All information issued from the process shall be supplied with an identifier, a time stamp and a quality flag including error identification in case of error. Units and full name of the information may not be required in the dynamic data if defined in the associated static meta-data.						Design requirement checked during the design phase	-	-
		[R73]		Calibration factor and conversion formula shall be configurable.						Design requirement checked during the design phase	-	-
		[R79]		The plant system I&C shall be able to manage different control types such as the state machines, the high level commands issued by the CODAC system towards the process, the unitary commands for test purposes, the plant system local control loops and the configuration commands from the CODAC system (not applicable to PSS).						Design requirement checked during the design phase	-	-
		[R81]		The plant system I&C shall maintain the status of all active alarms and shall transmit any change of this status (alarm raised, alarm cleared).						Design requirement checked during the design phase	-	-
		[R82]		The alarm shall carry information to the CODAC system to enable alarm reduction (not applicable to PSS).						Design requirement checked during the design phase	-	-
		[R83]		The alarms shall be raised in accordance with the operating states. This is needed to properly qualify alarms which are not significant in a given situation (not applicable to PSS).						Design requirement checked during the design phase	-	-
		[R84]		An alarm shall contain: A timestamp - A severity -An alarm identifier [TBD] -A process part identifier raising the alarm (source) - A text describing the condition that caused the alarm to be raised.						Design requirement checked during the design phase	-	-
		[R85]		A log message shall include: A time stamp - A process identifier according to the naming scheme - A text explaining the event - A message level (debug, info, warning, error).						Design requirement checked during the design phase	-	-
		[R86]		The following log messages shall be recorded with their qualifiers in the logging system: All timing, PSH, plant system Controller, PLC or embedded system events or state changes - All operations related to data configuration (creation/modification/deletions of variables, threshold change) - All transitions in operating states - All commands sent by central I&C systems - All binary state changes (e.g. valve opened or closed) - All events concerning an analogue variable or a group of analogue variables (threshold overshooting, out of range, discrepancy) - All variable validity changes - All actions done locally by operators (log on/off, local commands, variable tagging or forcing) - All local alarm acknowledgements.						Design requirement checked during the design phase	-	-
		[R87]		Remote control functions shall be available (reboot, configure, start, stop, switch to local / central control mode). These functions shall comply with the security rules of the ITER site.						Design requirement checked during the design phase	-	-
		[R88]		The plant system I&C shall be monitored in a homogeneous way in order to diagnose faults and facilitate fast recovery.						Design requirement checked during the design phase	-	-
		[R89]		The monitoring function shall encompass monitoring of plant system I&C functions and equipment.						Design requirement checked during the design phase	-	-
		[R90]		The plant system I&C shall be synchronised with ITER central time reference.							-	-
		[R91]		The equipment to be monitored shall include at least: Environment within cubicles - PSH hardware / software - Plant system controllers - I&C networks - CODAC system interface (in order to take local control of the plant system if there is a CODAC/CODAC network failure).						Design requirement checked during the design phase	-	-
		[R92]		Any monitored equipment and function shall supply status information with one of the following exclusive values: Fully operational - Partly operational (which means with limitations with respect to design parameters – performance, RAMI, OLC, …) - Not operational.						Design requirement checked during the design phase	-	-
		[R93]		Information on equipment performance shall be monitored. Performance information such as field bus, CPU load, memory usage or network bandwidth utilisation shall be recorded for capacity planning.						none	-	-
		[R94]		The plant system I&C events shall be reported in the logging and also alarms. This information shall also be propagated to the CODAC system.						Needs the whole conf of PS I&C to be checked	-	-
		[R96]		Plant system monitoring shall include self tests and live tests.						Design requirement checked during the design phase	-	-
		[R97]		The plant system shall be able to send acquired or computed information to the CODAC system in either raw data or in engineering units with conversion formula.						Design requirement checked during the design phase	-	-
		[R98]		Any configuration of parameters shall be possible with minimum disturbance to the rest of the plant system I&C and underlying process.						Design requirement checked during the design phase	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement description, refer to the approved document for details	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Specification												
Non-functional Requirements												
4.4.2	Non-functional Requirements	[R99]		Access to the plant system I&C shall be through approved access points and shall be in agreement with the ITER site security requirements. This encompasses both the physical access and the access through networks. ITER security requirements are described in TBD						Design requirement checked during the design phase	-	-
		[R100]		Plant system I&C shall restrict access to authorised systems/people.						Design requirement checked during the design phase	-	-
		[R101]		The availability of the plant systems I&C shall be compliant with the RAMI requirements of the plant system.						Design requirement checked during the design phase	-	-
		[R102]		Each CPU's load ratio of the processor module shall be less than 50% on average in any 10s period.						none	-	-
		[R103]		Usage of main memory shall not exceed 50% in any period.						none	-	-
		[R104]		Network and bus loads shall not exceed 50% in any 10 seconds period and for Ethernet based on the CSMA/CD principle it shall not exceed 30%.						none	-	-
		[R108]		Duration for update of information from sensors to the Plant Operation Network shall be less than 1 sec (for PSS, this is only applicable to communication between PSS and CSS).						Design requirement checked during the design phase	-	-
		[R109]		Duration for unitary commands from CODAC networks to actuators shall not exceed 1 sec.						Design requirement checked during the design phase	-	-
		[R110]		Plant system I&C participating in the diagnostics or plasma feedback control shall have specific performance requirements (not applicable to PSS).						Design requirement checked during the design phase	-	-
Software Infrastructure												
4.4.3	Software Infrastructure	[R112]		Communication between PS fast controllers and PSH shall use EPICS Channel Access.						Design requirement checked during the design phase	-	-
Self-Description Data												
4.4.6	Self-Description Data	[R120]		The SDD consist of: Plant system I&C unique identification - Command list - Alarms list - Set-points list - Plant system I&C design limits - Physical (raw) signals list (I/O) - Processed / converted signals list - Data streams list - Logging messages list - Definition of the plant system I&C state machine in accordance with the defined plant system operating states - Definitions of plant system I&C HMI - Initial values for run-time configuration used for plant system I&C start-up - Identification of source codes and binary packages of the plant system I&C specific software - Documentation.						Design requirement checked during the design phase	-	-
		[R121]		As a general principle, there shall be no hidden knowledge in the plant system I&C configuration. Whatever action is needed to configure the plant system I&C from scratch, it shall be an integral part of SDD (at least in the form of documentation).						Design requirement checked during the design phase	-	-
Operating States												
4.4.7	Operating States	[R122]		Plant system I&C shall implement COS and plant system operating states.						Design requirement checked during the design phase	-	-
Control Mode												
4.4.8	Control Mode	[R123]		Plant systems I&C shall always be in central control mode during normal operation.						Operation requirement to be checked at integrated commissioning	-	-
		[R124]		Central control is always done through the CODAC system operator or plant system operator from the MCR.						Operation requirement to be checked at integrated commissioning	-	-
		[R125]		As far as possible, the monitoring of the plant system by the CODAC system shall be maintained when the plant system is in local control and the state of the plant system shall reflect the control mode to be local.						Operation requirement to be checked at integrated commissioning	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Specification												
HMI												
Alarm handling												
4.4.10	Alarm handling	[R361]		The core principles underline this alarm philosophy are the following:						Design requirement checked during the design phase	-	-
		[R362]		Each alarm should be designed carefully according key principles:						Design requirement checked during the design phase	-	-
		[R363]		Number of configured alarms per operator shall be fewer than 100						Design requirement checked during the design phase	-	-
		[R364]		The number of alarms during the first 10 minutes of a major plant upset shall be less than ten.						Design requirement checked during the design phase	-	-
		[R365]		The alarm priority distribution is MAJOR (20 %) and MINOR (80 %)						Design requirement checked during the design phase	-	-
		[R366]		The average number of standing alarms shall be less than ten						Design requirement checked during the design phase	-	-
Plant System I&C Hardware Specification												
Plant System Slow Controller												
4.5.1	Plant System Slow Controller	[R131]		Slow Controllers shall use the ProfiNet field bus within their architecture up to the input/output card. The interface between PSH, PON and slow controllers shall be standard Ethernetcontrollers shall be standard Ethernet						Design requirement checked during the design phase	-	-
I&C Cubicles												
4.5.3	I&C Cubicles	[R161]		The I&C cubicles shall comply with ITER EMC and radiation policy						Design requirement checked during the design phase	-	-
I&C Signal Cabling Rules												
4.5.4	I&C Signal Cabling Rules	[R312]		A particular plant system I&C signal shall not be connected to different plant system I&Cs. If requested by several plant system I&Cs, the corresponding data shall be transmitted through the I&C networks.						Design requirement checked during the design phase	-	-
		[R313]		Direct cabled connections of I&C signals from a plant system I&C to another plant system I&C inside the same plant system or between two different plant systems are not allowed						Design requirement checked during the design phase	-	-
		[R314]		If the PSE and the I&C cubicle connected to it are not in same building or are located in the same building but far away from each other, then an optical fibre device shall be used.						Design requirement checked during the design phase	-	-
		[R315]		All the electrical cables used for transport of I&C signals will be single or multiple twisted pairs. Exceptions to this rule may apply for high frequency and high voltage analogue signals transmitted over a short distance. For such signals coaxial cables are recommended.						Design requirement checked during the design phase	-	-
Signal Interface												
4.5.5	Signal interface	[R318]		The ITER standards for I&C signals to be interfaced on ITER standard I&C controllers are as follow:						Design requirement checked during the design phase	-	-
Bondering - Powering												
4.5.6	Bondering - Powering	[R309]		All I&C cubicles shall comply with ITER policy for maintenance procedures, powering and earthing cable identification.						Design requirement checked during the design phase	-	-
		[R310]		The IEC 61000-5-2 technical standard is applicable for bonding of I&C components						Design requirement checked during the design phase	-	-
		[R306]		Use by temporary external equipment: NO external equipment should be plugged into the socket strips of the I&C cubicles. The exception to this is diagnostic and test equipment which may be connected for a limited time.						Operation requirement	-	-
Environment, Location and Volume Management												
4.5.7	Environment, Location and Volume Management	[R178]		The location of the instrumentation, cubicles and junction boxes shall depend on the functional requirements and shall be chosen so as to allow ease of access for initial installation and for later routine maintenance						Integration requirement to be checked during design and manufacture phases	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement description, refer to the approved document for details	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Specification												
Interface Specification between Plant System I&C and Central I&C systems												
Functional Interface												
5.2	Functional Interface	[R184]		The plant system I&C shall implement a functional interface to central CODAC systems compliant with the I&C requirements as expressed in the chapter 4 of that document						Design requirement checked during the design phase	-	-
		[R193]		Plant system I&C shall implement an interface (read and write data with sampling rates) to Synchronous Databus Network (see section 5.3.6) for plasma feedback control, if applicable.						Design requirement checked during the design phase	-	-
		[R194]		Plant system I&C shall implement an interface to Time Communication Network (see section 5.3.7) if high accuracy synchronization is required.						Design requirement checked during the design phase	-	-
		[R196]		Plant system I&C shall implement an interface to Audio-Video Network (see section 5.3.8) to communicate audio/video signals, if applicable.						Design requirement checked during the design phase	-	-
		[R197]		Plant system I&C shall implement an interface (read and write data) to the central interlock system, if applicable.						Design requirement checked during the design phase	-	-
		[R198]		Plant system I&C shall implement an interface (read and write data) to central safety systems, if applicable.						Design requirement checked during the design phase	-	-
Physical Interface												
5.3	Physical Interface	[R201]		Every plant system I&C shall be connected to PON.						Design requirement checked during the design phase	-	-
		[R202]		Only IO certified SDN interfaces shall be connected to SDN.						Design requirement checked during the design phase	-	-
		[R203]		Specific hardware and software required by SDN interface is supplied by IO.						Design requirement checked during the design phase	-	-
		[R204]		The SDN interface is located in the plant system controller.						Design requirement checked during the design phase	-	-
		[R205]		Only IO certified TCN interfaces shall be connected to TCN.						Design requirement checked during the design phase	-	-
		[R206]		Specific hardware and software required by the TCN interface is supplied by IO.						Design requirement checked during the design phase	-	-
		[R207]		The TCN Interface is located in the plant system controller.						Design requirement checked during the design phase	-	-
		[R211]		Only IO certified AVN interfaces shall be connected to AVN.						Design requirement checked during the design phase	-	-
		[R212]		Specific hardware and software required by the AVN interface is supplied by IO.						Design requirement checked during the design phase	-	-
		[R213]		The AVN Interface shall be located in the plant system controller.						Design requirement checked during the design phase	-	-
		[R301]		Only IO certified DAN interfaces shall be connected to DAN						Design requirement checked during the design phase	-	-
		[R302]		Specific hardware and software required by the DAN interface is supplied by IO.						Design requirement checked during the design phase	-	-
		[R303]		The DAN Interface shall be located in the plant system controller.						Design requirement checked during the design phase	-	-
		[R214]		PIS Controller shall interface to CIN if applicable.						Design requirement checked during the design phase	-	-
		[R215]		PSS Controller shall interface to CSN if applicable.						Design requirement checked during the design phase	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Specification												
Interlock I&C Specification												
Introduction												
6.1	Introduction	[R216]		Each function carried out by a plant system interlock I&C shall be defined, characterized and classified according to the guidelines given in this chapter or by an equivalent method.						Design requirement checked during the design phase	-	-
		[R217]		Each function shall be described with at least the following fields: Protection/function name: define a name or unique identifier - Protection/function description: a textual summary description of the function - Sensors: indicate what type and number of measurements are required for the function - Interlock logic: describe the interlock logic required for the function - Actuators: indicate what type and number of actuators are required for the function - Protection of machine: indicating which machine component is protected - Risk to protect: indicating which risk is being yes with this function - Risk description: a summary description of the risk being yes with this function - Risk class: Assign a class on the basis of the risk analysis and the Table 9-2-1 and Table 9-2-2.						Design requirement checked during the design phase	-	-
		[R218]		Each function shall be given a functional safety classification in the form of a safety integrity level (SIL) based on an established SIL assignment method (IEC 61508).						Design requirement checked during the design phase	-	-
		[R219]		The following technical performance requirements shall be identified for each function: RAMI parameters (Reliability, Availability, MTTR) - Maximum execution time.						Design requirement checked during the design phase	-	-
		[R220]		For each function, the list of environmental and/or physical constraints shall be identified: Space constraints - Ionizing radiation fields - Electromagnetic environment - ATEX requirements.						Design requirement checked during the design phase	-	-
		[R221]		When a function is allocated to a level of requirements, then the whole equipment necessary to the achievement of this function shall observe the corresponding requirements.						Design requirement checked during the design phase	-	-
		[R222]		If an equipment is involved in functions of different levels, then either the equipment shall be part of the highest level it contributes to or measures shall be taken to physically and electrically isolate the highest safety level part.						Design requirement checked during the design phase	-	-
		[R223]		The complexity of the I&C shall be restricted to the minimum required.						Design requirement checked during the design phase	-	-
		[R224]		The material organization of the I&C shall allow the containment of the most important functions for interlock within a perfectly identified physical entity.						Design requirement checked during the design phase	-	-
		[R225]		I&C shall be built using standardized architectures that are made of standard equipment in order to meet the specified functional and reliability requirements.						Design requirement checked during the design phase	-	-
		[R226]		This equipment (sensor, safety calculator, processing logic, network, actuator module...) shall be defined later in accordance with the functions to be performed. Slow Interlock PLCs have already been defined.						Design requirement checked during the design phase	-	-
		[R227]		Inviolability implies that everything should be implemented to restrict the risks of errors during: periodic test operations - corrective maintenance operations - modifications of the installation						Design requirement checked during the design phase	-	-
		[R228]		The equipment shall be designed to restrict the interventions required on the equipment for maintenance or preventive tests to the minimum by anticipating at the design stage the necessary means and interfaces for the performance of these tests.						Design requirement checked during the design phase	-	-
		[R229]		The equipment shall be fitted with specific access and intervention rules.						Design requirement checked during the design phase	-	-
		[R230]		The level of redundancy shall be set to reach the specified objectives for reliability and availability.						Design requirement checked during the design phase	-	-
		[R233]		Incoherencies in behaviour (control or measurements conflicts) between redundant equipment shall be reported to the operators.						Requirements attached to the design phase to be checked during SAT	-	-
		[R232]		The structure of the I&C shall ensure that common modes are mastered.						Design requirement checked during the design phase	-	-
		[R235]		If some equipment provides different level functions, some devices shall be implemented to avoid the highest level equipment being supplied with electric defects from the lowest level equipment.						Design requirement checked during the design phase	-	-
		[R236]		The material segregation shall be associated with a functional segregation, in order to avoid supplying incorrect information from a lower to a higher level.						Design requirement checked during the design phase	-	-
		[R238]		The redundant process lines: Shall be located in different areas and take into account the risks of mechanical stress, fire or flooding - If not, shall be fitted with protective equipment to ensure that the redundant process lines shall not be affected by the same aggravating factors - Shall be fitted with devices that avoid spreading electrical defects among redundant equipment - Shall be fitted with ancillary systems (power supply, cooling device) which have compatible redundancy levels.						Design requirement checked during the design phase	-	-
		[R292]		An incident shall not lead to the loss of several redundant process lines.						Requirements attached to the design phase to be checked during SAT	-	-
		[R240]		The diagnostic coverage shall be defined in accordance with the safety failure fraction required for the safety integrity level of the equipment. (See IEC 61508-2 §7.4.3.1.4).						Design requirement checked during the design phase	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement description, refer to the approved document for details	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Specification												
Interlock I&C Specification												
Interlock I&C Architecture												
6.2	Interlock I&C Architecture	[R325]		Each PIS sends to the CIS: Its own state - The PIS commands sent to the process - The signals used by CIS or other PIS for making decisions - The information to be displayed on CIS operator desks - The information enabling PIS monitoring and PIS data archiving						Design requirement checked during the design phase	-	-
		[R326]		The CIS sends to the PIS: CPI commands related to this PIS						Design requirement checked during the design phase	-	-
		[R327]		Interface between PIS and CIS relies on CIN.						Design requirement checked during the design phase	-	-
		[R328]		CIN is built redundant.						Design requirement checked during the design phase	-	-
		[R329]		All the PIS are synchronised on an ITER central clock.						Design requirement checked during the design phase	-	-
		[R330]		Inter-PS communication between PS flows through CIS using CIN. There may be some hardwired links between Plant Interlock Systems for performance reasons: they will be dealt as deviations as stated in chapter 8. In that case, only binary information will be exchanged.						Design requirement checked during the design phase	-	-
		[R243]		Plant Interlock System Controllers shall comply with the assigned SIL level.						Design requirement checked during the design phase	-	-
		[R333]		The slow architecture is based on COTS industrial components (Programmable Logic Controllers, (PLC).						Design requirement checked during the design phase	-	-
Interlock I&C Software Specification												
6.4	Interlock I&C Software Specification	[R244]		Interlock I&C software shall comply with the assigned SIL level.						Design requirement checked during the design phase	-	-
		[R245]		The software specification shall describe in quantitative terms the performance criteria (accuracy), the time constraints (response time) and the dimensional constraints (size of memory), with the tolerances and the possible margins.						Design requirement checked during the design phase	-	-
		[R247]		The Interlock I&C shall implement the following functions: Detect anomalous situations on the basis of simple or complex algorithms from the measurement of field values, the operational status of the monitored equipment and of the overall machine - Generate protection events (events and inhibits) - Command protection actuators operated on the basis of a set of conditions and events.						Design requirement checked during the design phase	-	-
		[R248]		The performance shall be compatible with the SIL level required by the interlock functions.						Design requirement checked during the design phase	-	-
		[R249]		The I&C self diagnostics (Diagnostic Coverage) shall be compatible with the SIL level required by the interlock functions.						Design requirement checked during the design phase	-	-
		[R250]		The software infrastructure for interlock I&C software shall comply with the assigned SIL level.						Design requirement checked during the design phase	-	-
		[R251]		The operating systems for interlock I&C software shall comply with the assigned SIL level.						Design requirement checked during the design phase	-	-
		[R252]		The programming languages and tools for interlock I&C software shall comply with the assigned SIL level. For the PLCs, the safety matrix and Continuous Functional Chart (CFC) shall be used.						Design requirement checked during the design phase	-	-
		[R335]		The Interlocks can be enabled or disabled independently of the Plant System Operating States of rest of the I&C.						Design requirement checked during the design phase	-	-
Interlock I&C Hardware Specification												
6.5	Interlock I&C Hardware Specification	[R253]		The plant interlock system slow controller shall comply with the assigned SIL level.						Design requirement checked during the design phase	-	-
		[R254]		Slow controllers shall use the Siemens Simatic S7-400 FH range for both SIL-2 and SIL-3 PLCs.						Design requirement checked during the design phase	-	-
		[R257]		The plant interlock system network shall comply with the assigned SIL level.						Design requirement checked during the design phase	-	-
		[R336]		Communication within the PIS slow controllers uses the ProfiSafe field buses.						Design requirement checked during the design phase	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Specification												
Safety I&C Specification												
7	Safety I&C Specification	[R259]		Each function shall be described with at least the following fields:						Design requirement checked during the design phase	-	-
		[R260]		Each function shall be given a safety classification in the form of a safety integrity level (IEC 61508) based on one of the methods indicated in the standard or equivalent.						Design requirement checked during the design phase	-	-
		[R261]		The following technical performance requirements shall be identified for each function:						Design requirement checked during the design phase	-	-
		[R262]		For each function, the list of environmental and/or physical constraints shall be identified:						Design requirement checked during the design phase	-	-
		[R293]		The Occupational Safety Plant Safety System (PSS-OS) shall provide I&C Safety functions for the protection of the people and the environment against all conventional hazards						Design requirement checked during the design phase	-	-
		[R294]		The Plant Safety functions shall provide locally visual and audible warnings and alarms in the event of a hazard.						Design requirement checked during the design phase	-	-
		[R295]		The Plant Safety functions shall communicate all hazards, warnings and alarms to the Central Safety System.						Design requirement checked during the design phase	-	-
		[R263]		All safety functions shall be designed on the basis of their SIL classifications (1, 2 or 3 considering the instructions of the IEC 61508 standard).						Design requirement checked during the design phase	-	-
		[R265]		When a function is allocated to a level of requirements, then all equipment necessary to the achievement of this function shall observe the corresponding requirements.						Design requirement checked during the design phase	-	-
		[R266]		If an equipment is involved in functions of different levels, then						Design requirement checked during the design phase	-	-
		[R267]		The plant system safety I&C functions shall be allocated using the set of standard conceptual architectures given in this chapter.						Design requirement checked during the design phase	-	-
		[R268]		Each plant system safety I&C shall be represented by a composition of the set of standard conceptual architectures given in this chapter.						Design requirement checked during the design phase	-	-
		[R269]		Adequate physical separation between systems shall be demonstrated by following the standard IEC 60709.						Design requirement checked during the design phase	-	-
		[R270]		The different PSS-OS are not able to be interfaced with the mini-CODAC						Design requirement checked during the design phase	-	-
		[R272]		The software specification shall describe in quantitative terms the performance criteria (accuracy), the time constraints (response time) and the dimensional constraints (size of memory), with the tolerances and the possible margins.						Design requirement checked during the design phase	-	-
		[R273]		The derived functions introduced during the software development process shall be identified. The consequences of the errors of these software functions shall be studied at the system level. Derived functions shall be functions not expressed in the system specification but necessary for the functioning of the system (for example: functions of communication inherent to the internal architecture of the system, functions of system breakdown detection …)						Design requirement checked during the design phase	-	-
		[R277]		Once Occupational risk is eliminated, the operator has to reset the function to re-authorize the use of the actuator. It is not possible to						Design requirement checked during the design phase	-	-
		[R341]		PSS-OS shall integrate system diagnostic functions with auto-diagnostic capabilities						Design requirement checked during the design phase	-	-
		[R342]		PSS-OS shall integrate signal diagnostic functions						Design requirement checked during the design phase	-	-
		[R343]		PSS-OS shall integrate maintenance override functions						Design requirement checked during the design phase	-	-
		[R344]		PSS-OS communicate all safety events to the Central Safety System						Design requirement checked during the design phase	-	-
		[R345]		The logging data shall include						Design requirement checked during the design phase	-	-
		[R346]		System management shall be performed with safety dedicated safety engineering tools						Design requirement checked during the design phase	-	-
		[R347]		The performance shall be compliant with the SIL level (IEC 61508) required by the Safety functions						Design requirement checked during the design phase	-	-
		[R348]		The I&C self-diagnostics (Diagnostic Coverage) shall be compatible with the SIL level						Design requirement checked during the design phase	-	-
		[R349]		The software infrastructure for Occupational Safety I&C software shall be based on Siemens COTS operating systems and applications that comply with the assigned SIL level, up to SIL-3 (61508).						To be checked by Jean-Marc	-	-
		[R350]		Programming tools shall use Siemens dedicated engineering tools like Safety Matrix						To be checked by Jean-Marc	-	-
		[R351]		Occupational Safety functions should be operational in all ITER operational states and could be disabled only when the absence of risk can be demonstrated						Design requirement checked during the design phase	-	-
		[R352]		PSS-OS controllers shall use the Siemens Simatic S7-400 FH range for both SIL-3 PLCs. (IEC 61508						To be checked by Jean-Marc	-	-
		[R354]		PSS-OS controllers shall use the ProfiSafe on Profinet						To be checked by Jean-Marc	-	-
		[R357]		The PBS in charge of the plant system shall perform the Cabling between PSS, process and up to the CODAC hutch						Out of scope	-	-
		[R356]		PSS-OS cubicles shall be powered by two independent Class II-IP power supply and Class IV power supply.						Design requirement checked during the design phase	-	-
		[R358]		Occupational Safety system components shall be accredited for to the identified environment al constraints and be installed in locations where environmental conditions are yes by this accreditation of the equipment						Design requirement checked during the design phase	-	-
		[R359]		Where increased environmental hazards are imposed on I&C equipment by the Plant System design, it will be treated as an exception						Design requirement checked during the design phase	-	-
		[R360]		The plant safety system I&C lifecycle and development processes will follow the requirements of IEC 61508						Design requirement checked during the design phase	-	-

PCDH section#	PCDH section title	PCDH Req#	Severity level	Requirement Description	Test req.	C1 I&C Doc.	C2 I&C HW	C3 I&C SW	C4 I&C funct.	Comments	FAT	SAT
Deviations Policy												
8	Deviations Policy	[R281]		Requests for deviations from and non-conformance with the requirements of the ITER Plant Control Design Handbook shall be made to the IO in writing following the procedures detailed in [RD11], [RD19] and [RD12]. The decision on the acceptance of the non-conformance report shall be made by the plant system central I&C responsible officer of the IO.						Design requirement checked during the design phase	-	-
		[R290]		IO reserves rights to modify these technical specifications during the execution of the procurement. The consequence of such modifications shall be mutually agreed between plant system I&C supplier and IO.						Design requirement checked during the design phase	-	-

9 PCDH requirements mapping matrix

The following matrix gives the list of PCDH requirements addressed by each of the test campaigns described in the section.

I&C matrix for FAT/SAT and PCDH requirements (DYY8R9)